Claims

[c1] A method of relaxing a stress present in a film contacting a base layer, comprising oxidizing said film to reduce a magnitude of said stress by supplying atomic oxygen to a surface of said film.

[c2] The method of claim 1 wherein said stress has at least one type selected from the group consisting of tensile and compressive.

[c3] The method of claim 2 wherein said atomic oxygen is generated through excitation by high electron density plasma at a temperature below 700 degrees Celsius.

[c4] The method of claim 1 wherein said atomic oxygen is produced by one or more processes selected from the group consisting of electrical discharge, electromagnetic radiation having a wavelength selected from the group consisting of infrared, visible, ultraviolet and X-ray portions of the spectrum, application of heat, electron beam, ion beam, chemical processes, chemical decomposition of ozone, and chemical reactions involving molecular oxygen.

[c5] The method of claim 4 wherein said atomic oxygen is produced at one or more locations being at least one of near said surface and remote from said surface.

[c6] The method of claim 1 further comprising annealing said oxidized film, said annealing changing little the reduced magnitude of the stress in said oxidized film.

[c7] The method of claim 1 further comprising masking selected areas of said stressed film such that said stress is maintained in said selected areas during said oxidizing process.

[c8] A method of fabricating an integrated circuit including a p-type field effect transistor (PFET) and an n-type field effect transistor (NFET), said NFET and said PFET each having a channel region and a source and drain region, said method comprising:
forming a PFET gate stack and an NFET gate stack over a single-crystal region of a semiconductor, said PFET gate stack and said NFET gate stack each having a gate conductor overlying a gate dielectric formed on a main surface of said single-crystal region and spacers including a first material formed on sidewalls of said gate conductor;
forming a film having a stress over said source and drain regions of said NFET and said PFET;
blocking said source and drain regions of either said

NFET or said PFET with a mask; and
oxidizing portions of said film by supplying atomic oxygen to a surface of said film in areas not blocked by said mask to reduce a magnitude of said stress in said film over said source and drain regions of said PFET or said NFET, respectively.

[c9] The method of claim 8 wherein said source and drain regions of said NFET are blocked by said mask and said stress is relaxed in said PFET.

[c10] The method of claim 8 wherein said source and drain regions of said PFET are blocked by said mask and said stress is relaxed in said NFET.

[c11] The method of claim 8 wherein said atomic oxygen is produced by one or more processes selected from the group consisting of electrical discharge, electromagnetic radiation having a wavelength selected from the group consisting of infrared, visible, ultraviolet and X-ray portions of the spectrum, application of heat, electron beam, ion beam, chemical processes, chemical decomposition of ozone, and chemical reactions involving molecular oxygen.

[c12] The method of claim 8 wherein said atomic oxygen is produced at one or more locations being at least one of

near said surface and remote from said surface.

[c13] The method of claim 8 wherein said atomic oxygen is generated through excitation by high electron density plasma at a temperature below 700 degrees Celsius.

[c14] The method of claim 13 wherein said oxidizing includes subjecting said stressed film to an ionized ambient of an oxygen-bearing gas.

[c15] The method of claim 14 wherein said oxygen-bearing gas is selected from the group consisting oxygen (O_2), water vapor (H_2O), nitrous oxide (N_2O), nitric oxide (NO), and ozone (O_3).

[c16] The method of claim 8 further comprising annealing said oxidized film at a temperature above 500 degrees Celsius, said annealing changing little the reduced magnitude of the stress in said oxidized film.

[c17] The method of claim 13 wherein said oxidizing is conducted using a high density plasma reactor.

[c18] The method of claim 17 wherein said oxidizing reduces the magnitude of stress in said film by forming an oxide layer on said film through exposure to a plasma including a mixture of oxygen-bearing gas and diluent gas normally non-reactive to oxygen.

[c19] The method of claim 18, wherein said mixture is ionized to create said plasma having an electron density of at least about 1 x $10^{12} cm^{-3}$.

[c20] The method of claim 19, wherein said diluent gas is selected from the group consisting neon (Ne), argon (Ar), Krypton (Kr), xenon (Xe) and Radon (Rn).

[c21] An integrated circuit including a p-type field effect transistor (PFET) and an n-type field effect transistor (NFET), said NFET and said PFET each having a channel region and a source and drain region, comprising:
a PFET gate stack and an NFET gate stack formed over a substrate including a single-crystal semiconductor region, said PFET gate stack and said NFET gate stack each having a gate conductor overlying a gate dielectric formed on a main surface of said single-crystal region and spacers including a first material formed on sidewalls of said gate conductor;
a film having a stress formed over said source and drain regions of said NFET and said PFET, said stress having a reduced magnitude over said source and drain regions of either said NFET or said PFET as a result of oxidizing portions of said film over said source and drain regions of said NFET or said PFET, respectively, by exposure to atomic oxygen.

[c22] The integrated circuit of claim 21 wherein said stress is tensile and said portions of said film are oxidized to reduce the magnitude of said stress over said source and drain regions of said PFET.

[c23] The integrated circuit of claim 21 wherein said stress is compressive and said portions of said film are oxidized to reduce the magnitude of said stress over said source and drain regions of said NFET.

[c24] The method of claim 21 wherein the atomic oxygen is produced by one or more processes selected from the group consisting of electrical discharge, electromagnetic radiation having a wavelength selected from the group consisting of infrared, visible, ultraviolet and X-ray portions of the spectrum, application of heat, electron beam, ion beam, chemical processes, chemical decomposition of ozone, and chemical reactions involving molecular oxygen.

[c25] The integrated circuit of claim 24 wherein said film is annealed, said annealing changing little the reduced magnitude of stress of said film.

[c26] The integrated circuit of claim 21 wherein said substrate consists essentially of silicon.

[c27] The integrated circuit of claim 21 wherein said substrate includes one or more materials selected from the group consisting of silicon, silicon germanium, silicon dioxide, silicon carbide, and silicon nitride.

[c28] The integrated circuit of claim 21 wherein said substrate is semiconductor-on-insulator substrate.

[c29] The integrated circuit of claim 21 wherein said semiconductor-on-insulator substrate is a silicon-on-insulator (SOI) substrate.

[c30] A structure comprising:
a base layer;
an oxidized film contacting said base layer, said film having a stress and being oxidized to relax the stress through exposure to atomic oxygen at a surface of said film.